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KARMA: Kalman-based autoregressive moving average modeling and inference for formant and antiformant tracking

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Vocal tract resonance characteristics in acoustic speech signals are classically tracked using frame-by-frame point estimates of formant frequencies followed by candidate selection and smoothing using dynamic programming methods that minimize ad hoc cost functions. The goal of the current work is to provide both point estimates and associated uncertainties of center frequencies and bandwidths in a statistically principled state-space framework. Extended Kalman (K) algorithms take advantage of a linearized mapping to infer formant and antiformant parameters from frame-based estimates of autoregressive moving average (ARMA) cepstral coefficients. Error analysis of KARMA, WaveSurfer, and Praat is accomplished in the all-pole case using a manually marked formant database and synthesized speech waveforms. KARMA formant tracks exhibit lower overall root-mean-square error relative to the two benchmark algorithms, with third formant tracking more challenging. Antiformant tracking performance of KARMA is illustrated using synthesized and spoken nasal phonemes. The simultaneous tracking of uncertainty levels enables practitioners to recognize time-varying confidence in parameters of interest and adjust algorithmic settings accordingly.

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